Afro-Asian Journal of Scientific Research (AAJSR)
المجلة الأفروآسيوية للبحث العلمي
E-ISSN: 2959-6505
Volume 4, Issue 1, 2026
Page No: 422-428
Website: https://aajsr.com/index.php/aajsr/index
SJIFactor 2024: 5.028 ISI 2025: 0.915 معامل التأثير العربي (AIF) 2025: 0.76

Biochemical Adaptations of Dromedary Camels to Seasonal Environmental Stress

Bouzeed S. Boukhazeem*
Faculty of Nursing, Tobruk University, Tobruk, Libya

التكيفات الفسيولوجية والدموية للإبل وحيدة السنام في مواجهة الإجهاد البيئي الموسمي في البيئات القاحلة

بوزيد شحات بوخزيم*
كلية التمريض، جامعة طبرق، طبرق، ليبيا

*Corresponding author: bouzeed.boukhazeem@tu.edu.ly

Received: January 08, 2026	Accepted: February 12, 2026	Published: February 23, 2026

Abstract:
Physiological adaptation to environmental stress is a defining feature of dromedary camels (Camelus dromedarius), particularly in arid ecosystems characterized by seasonal thermal load and water limitation. Such adaptation involves integrated hematological and metabolic regulation aimed at maintaining homeostasis under fluctuating environmental and biological conditions. The present study evaluated age- and season-related physiological variation in clinically healthy dromedary she-camels raised under extensive pastoral systems in eastern Libya, using hematological indices as integrative indicators of physiological and metabolic adjustment. Female camels were categorized into three age groups (3–<6 years, 6–10 years, and >10 years) and sampled across four seasons (winter, spring, summer, and autumn). Hematological parameters assessed included white blood cell count (WBC), red blood cell count (RBC), hemoglobin concentration (Hb), packed cell volume (PCV), and erythrocyte indices (MCV, MCH, and MCHC). Data were analyzed using analysis of variance to determine the effects of age and season. Advancing age was associated with increased leukocyte counts and higher erythrocytic parameters, indicating age-related modulation of immune activity and oxygen transport capacity. Seasonal variation exerted a pronounced effect on erythrocytic profiles, with higher RBC, PCV, and Hb values observed during cooler seasons, consistent with improved hydration status and reduced thermal stress. Variations in erythrocyte indices across age groups and seasons suggest adaptive regulation of red blood cell morphology and hemoglobin content in response to environmental and physiological demands. These findings demonstrate that age and season significantly shape physiological homeostasis in dromedary she-camels. Although assessed through hematological markers, the observed patterns reflect broader metabolic and adaptive processes underlying camel resilience to arid environmental stress. The study provides region-specific baseline information supporting physiologically informed interpretation of laboratory data in camels raised under arid pastoral conditions.

Keywords: Camelus dromedarius; physiological adaptation; hematological indices; age; seasonality; arid environments.

الملخص:
يُعد التكيف الفسيولوجي مع الإجهاد البيئي من السمات الجوهرية التي تميز الإبل وحيدة السنام (Camelus dromedarius)، لا سيما في البيئات القاحلة التي تتسم بارتفاع درجات الحرارة وتذبذب توافر الموارد المائية على نحو موسمي. ويعتمد هذا التكيف على منظومة متكاملة من التنظيمات الدموية والتمثيلية التي تسهم في الحفاظ على الاتزان الداخلي للكائن الحي تحت ظروف بيئية متغيرة. هدفت هذه الدراسة إلى تقييم التباين الفسيولوجي المرتبط بكل من العمر والتغيرات الموسمية لدى إناث الإبل وحيدة السنام السليمة سريريًا، والمرباة ضمن نظم رعوية تقليدية في شرق ليبيا، وذلك بالاعتماد على المؤشرات الدموية بوصفها أدوات تكاملية لتفسير الاستجابات الفسيولوجية والتمثيلية. تم تصنيف الحيوانات إلى ثلاث فئات عمرية (3 إلى أقل من 6 سنوات، 6–10 سنوات، وأكثر من 10 سنوات)، وجُمعت العينات عبر أربعة فصول من السنة (الشتاء، الربيع، الصيف، والخريف). وشملت المعايير الدموية المدروسة عدد كريات الدم البيضاء، وعدد كريات الدم الحمراء، وتركيز الهيموغلوبين، وحجم الخلايا المرصوصة، بالإضافة إلى مؤشرات كريات الدم الحمراء (MCV، MCH، MCHC). وقد تم تحليل البيانات إحصائيًا باستخدام تحليل التباين لتحديد تأثير كل من العمر والموسم. أظهرت النتائج وجود علاقة واضحة بين التقدم في العمر وزيادة عدد الكريات البيضاء وارتفاع مؤشرات الكريات الحمراء، مما يعكس تعديلات فسيولوجية مرتبطة بالنشاط المناعي وكفاءة نقل الأكسجين. كما تبين أن التغيرات الموسمية تؤثر بشكل ملحوظ على الخصائص الدموية، حيث سُجلت قيم أعلى لكريات الدم الحمراء والهيموغلوبين وحجم الخلايا المرصوصة خلال الفصول الباردة، وهو ما يُعزى إلى تحسن حالة الترطيب وانخفاض الإجهاد الحراري. وتشير التغيرات الملحوظة في مؤشرات كريات الدم الحمراء عبر الفئات العمرية والفصول المختلفة إلى وجود آليات تنظيم تكيفي في بنية الخلايا ومحتواها من الهيموغلوبين، بما يتلاءم مع المتطلبات البيئية والفسيولوجية المتغيرة. تؤكد هذه النتائج أن كلًا من العمر والتغيرات الموسمية يلعبان دورًا حاسمًا في تشكيل الاتزان الفسيولوجي لدى إناث الإبل وحيدة السنام. كما تعكس الأنماط الدموية المرصودة عمليات تكيفية أوسع تسهم في تعزيز قدرة الإبل على التكيف مع ظروف الإجهاد البيئي في البيئات القاحلة. وتوفر هذه الدراسة بيانات مرجعية ذات طابع إقليمي تدعم التفسير الدقيق للنتائج المخبرية، وتسهم في تحسين التقييم الصحي والإدارة البيطرية للإبل في النظم الرعوية.

الكلمات المفتاحية: الأبل وحيدة السنام، التكيف الفسيولوجي، المؤشرات الدموية (الهيماتولوجية)، العمر والتقدم العمري، التباين الموسمي، الإجهاد البيئي، البيئات القاحلة وشبه القاحلة.

Introduction:

1. Physiological Adaptation of Dromedary Camels to Arid Environments:

Dromedary camels (*Camelus dromedarius*) are among the most physiologically adapted domestic species, capable of surviving and remaining productive under extreme arid and semi-arid conditions. These environments are characterized by high ambient temperatures, limited and irregular water availability, and seasonal fluctuations in forage quality. The ability of camels to tolerate such stressors depends on integrated physiological mechanisms that regulate body water balance, oxygen transport, immune function, and metabolic stability (Schmidt-Nielsen, 1997; Faye & Bengoumi, 2018).

Unlike other domestic ruminants, camels exhibit distinctive circulatory and cellular adaptations that support homeostasis during dehydration and heat stress. These include unique erythrocyte morphology, efficient plasma volume regulation, and flexible immune responses, all of which contribute to sustained physiological performance under harsh environmental conditions (Faye & Bengoumi, 2018).

2. Hematological Parameters as Indicators of Physiological Homeostasis:

Hematological parameters are widely used as integrative indicators of physiological status in domestic animals. In camels, measures such as white blood cell count (WBC), red blood cell count (RBC), hemoglobin concentration (Hb), packed cell volume (PCV), and erythrocyte indices (MCV, MCH, and MCHC) provide critical information on immune activity, oxygen transport capacity, hydration status, and circulatory efficiency (Kaneko et al., 2008; Thrall et al., 2012).

Interpretation of camel hematology requires particular caution, as normal physiological adaptation to environmental stress may produce values that differ substantially from those of other livestock species without indicating pathology. Hematological variation in camels often reflects adaptive responses to environmental load, including heat stress and dehydration, rather than disease processes (Faye & Bengoumi, 2018). Therefore, contextual factors such as age and season must be considered to avoid diagnostic misclassification.

3. Influence of Age on Hematological Profiles:

Age represents a key intrinsic factor influencing physiological function and hematological regulation in mammals. Across species, advancing age is associated with gradual changes in immune system activity, erythropoiesis, and blood cell turnover, which may alter baseline hematological values even in clinically healthy individuals (López-Otín et al., 2013; Franceschi et al., 2018).

In camels, age-related variation in hematological parameters has been reported, particularly in leukocyte counts and erythrocytic indices. Older animals often exhibit higher WBC counts, reflecting cumulative antigen exposure and immune system remodeling, while erythrocytic parameters may increase or stabilize with physiological maturity (Ahmadi-Hamedani et al., 2014; Abdalmula et al., 2023). These changes are generally considered part of normal physiological ageing rather than indicators of disease, emphasizing the need for age-aware interpretation of hematological data.

4. Seasonal Effects on Hematological Regulation:

Seasonal variation is a major extrinsic factor shaping physiological responses in camels raised under natural pastoral conditions. Seasonal changes in temperature, humidity, water availability, and feed resources impose varying physiological demands that are reflected in hematological profiles. Several studies have reported higher RBC counts, PCV, and hemoglobin concentrations during cooler seasons, often attributed to improved hydration status and reduced thermal stress, whereas warmer seasons are associated with lower erythrocytic values due to plasma volume expansion and thermoregulatory adaptation (Amin et al., 2007; Babeker et al., 2013).

Seasonal variation may also influence leukocyte profiles, reflecting changes in environmental pathogen exposure, nutritional transitions, and physiological stress associated with climatic shifts. These seasonal hematological adjustments represent adaptive mechanisms aimed at preserving circulatory stability and oxygen delivery under fluctuating environmental conditions (Faye & Bengoumi, 2018). Given the reliance on hematological analysis for health assessment and disease diagnosis, the lack of context-specific, age- and season-aware data may compromise clinical interpretation and herd management decisions. Addressing this gap is particularly important for female camels, which play a central role in reproduction and herd sustainability.

Aim of the Study:

The present study aimed to evaluate age- and season-related physiological variation in hematological parameters of clinically healthy dromedary she-camels raised under arid pastoral conditions in eastern Libya.

Materials and Methods:

Study Area:

The study was conducted in eastern Libya, a region characterized by an arid Mediterranean climate with marked seasonal variation. Summers are typically hot and dry, while winters are relatively mild with limited rainfall. Camels in this region are predominantly raised under extensive pastoral systems, relying on natural grazing and seasonal water availability. These environmental conditions provide a suitable setting for evaluating age- and season-related physiological variation in camels (Faye & Bengoumi, 2018).

Animals and Experimental Design:

Clinically healthy dromedary she-camels (*Camelus dromedarius*) were selected from traditional pastoral herds. Only non-pregnant and non-lactating females were included to minimize physiological variability associated with reproduction. Health status was assessed through physical examination and herd owner records, and animals showing signs of disease or having a recent history of medical treatment were excluded.

Based on dentition and available herd records, animals were classified into three age groups:

- **3–<6** years.
- **6–10** years.
- **>10** years.

This age stratification reflects commonly used groupings in camel physiological and hematological studies and allows assessment of age-related variation across adulthood (Ahmadi-Hamedani et al., 2014; Abdalmula et al., 2023).

Seasonal Classification and Sampling:

Blood samples were collected across four seasons, winter, spring, summer, and autumn, to capture natural climatic variation in the study area. Sampling was performed during the midpoint of each season to reduce the influence of transitional environmental conditions. All samples were collected during morning hours to minimize potential diurnal variation in hematological parameters (Thrall et al., 2012).

Blood Collection:

Blood samples were obtained by jugular venipuncture using sterile disposable needles. Samples were collected into tubes containing ethylenediaminetetraacetic acid (EDTA) as an anticoagulant for hematological analysis. Following collection, samples were transported promptly to the laboratory and analyzed within an appropriate time frame to preserve sample integrity.

Hematological Analysis:

Hematological parameters were determined using standard veterinary hematology techniques. The following parameters were evaluated:

- White blood cell count (WBC)
- Red blood cell count (RBC)
- Hemoglobin concentration (Hb)
- Packed cell volume (PCV)
- Mean corpuscular volume (MCV)
- Mean corpuscular hemoglobin (MCH)
- Mean corpuscular hemoglobin concentration (MCHC)

These parameters were selected as integrative indicators of immune status, oxygen transport capacity, hydration balance, and circulatory efficiency in camels (Kaneko et al., 2008; Thrall et al., 2012). Routine quality control procedures were applied to ensure analytical accuracy and repeatability.

Statistical Analysis:

Data are presented as **mean ± standard error of the mean (SEM)**. Statistical analyses were performed using standard statistical software.

- The effects of **age** and **season** on hematological parameters were evaluated using **one-way analysis of variance (ANOVA)**.
- When significant differences were detected, post hoc multiple comparison tests were applied to identify differences among groups.

Statistical significance was set at **P < 0.05**. Due to the structure of the available dataset, interaction effects between age and season were not formally tested.

Results:

Hematological parameters of dromedary she-camels were evaluated according to **age group** and **season**. Results are presented as **mean ± standard error of the mean (SEM)**. Statistical differences among groups were assessed using one-way ANOVA, and significance was set at $P < 0.05$.

- **Effect of Age and Season on White Blood Cell Count (WBC)**:

White blood cell counts differed significantly among age groups and across seasons. The highest WBC values were recorded in camels older than 10 years, whereas younger age groups showed lower values. Seasonal variation was also observed, with significant differences among winter, spring, summer, and autumn.

Table (1): Effect of age and season on white blood cell count (WBC $\times 10^3/mm^3$) in dromedary she-camels.

Factor	Group	WBC ($\times 10^3/mm^3$)
Age group	3–<6 years	14.679 ± 0.374^a
	6–10 years	14.973 ± 0.410^a
	>10 years	18.059 ± 0.508^b
Season	Winter	13.158 ± 0.554^a
	Spring	19.201 ± 0.498^b
	Summer	13.695 ± 0.538^a
	Autumn	17.561 ± 0.403^c

Different superscript letters within each factor indicate significant differences ($P < 0.05$).

- **Effect of Age and Season on Red Blood Cell Count (RBC):**

Red blood cell counts varied significantly with age and season. Middle-aged and older camels showed higher RBC values compared with younger animals. Seasonal differences were evident, with marked variation among the four seasons.

Table (2): Effect of age and season on red blood cell count (RBC $\times 10^6/mm^3$) in dromedary she-camels.

Factor	Group	RBC ($\times 10^6/mm^3$)
Age group	3–<6 years	6.733 ± 0.088^a
	6–10 years	7.473 ± 0.096^b
	>10 years	7.221 ± 0.119^b
Season	Winter	8.943 ± 0.130^a
	Spring	6.142 ± 0.117^b
	Summer	7.024 ± 0.126^c
	Autumn	$6.460 \quad 0.094^d$

Different superscript letters within each factor indicate significant differences ($P < 0.05$).

- **Effect of Age and Season on Hemoglobin Concentration (Hb):**

Hemoglobin concentration did not differ significantly among age groups. However, significant seasonal variation was observed, with differences among winter, spring, summer, and autumn.

Table (3): Effect of age and season on hemoglobin concentration (Hb, g/dL) in dromedary she-camels.

Factor	Group	Hb (g/dL)
Age group	3–<6 years	12.098 ± 0.114[a]
	6–10 years	12.089 ± 0.126[a]
	>10 years	11.802 ± 0.156[a]
Season	Winter	14.958 ± 0.170[a]
	Spring	9.837 ± 0.153[b]
	Summer	11.007 ± 0.165[c]
	Autumn	12.182 ± 0.123[d]

Different superscript letters within each factor indicate significant differences ($P < 0.05$).

Effect of Age and Season on Packed Cell Volume (PCV):

Packed cell volume showed significant differences among age groups, with higher values observed in middle-aged and older camels. Seasonal variation in PCV was also significant.

Table (4): Effect of age and season on packed cell volume (PCV, %) in dromedary she-camels.

Factor	Group	PCV (%)
Age group	3–<6 years	26.015 ± 0.321[a]
	6–10 years	27.622 ± 0.352[b]
	>10 years	27.120 ± 0.437[b]
Season	Winter	32.801 ± 0.476[a]
	Spring	23.822 ± 0.428[b]
	Summer	25.509 ± 0.462[c]
	Autumn	25.543 ± 0.346[c]

Different superscript letters within each factor indicate significant differences ($P < 0.05$).

- **Effect of Age and Season on Erythrocyte Indices:**

Mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration varied significantly with both age and season.

Table (5): Effect of age and season on erythrocyte indices in dromedary she-camels.

Factor	Group	MCV (fL)	MCH (pg)	MCHC (%)
Age group	3–<6 years	39.571 ± 0.501[a]	18.786 ± 0.194[a]	47.025 ± 0.519[a]
	6–10 years	36.982 ± 0.550[b]	16.196 ± 0.213[b]	43.793 ± 0.569[b]
	>10 years	37.978 ± 0.682[ab]	16.399 ± 0.264[b]	43.599 ± 0.706[b]
Season	Winter	36.701 ± 0.742[a]	16.863 ± 0.288[a]	46.137 ± 0.768[a]
	Spring	39.094 ± 0.668[b]	16.077 ± 0.259[b]	41.471 ± 0.692[b]
	Summer	36.345 ± 0.721[a]	15.682 ± 0.280[b]	43.175 ± 0.746[b]
	Autumn	40.568 ± 0.540[b]	19.886 ± 0.210[c]	48.439 ± 0.559[c]

Different superscript letters within each factor indicate significant differences ($P < 0.05$).

Discussion:

The present study demonstrates that hematological parameters in dromedary she-camels raised under arid pastoral conditions in eastern Libya are significantly influenced by both **age** and **season**, confirming that physiological homeostasis in camels is dynamic and context-dependent. These findings reinforce the concept that hematological profiles in camels reflect adaptive physiological regulation rather than static reference values and must be interpreted in light of intrinsic and extrinsic factors (Faye & Bengoumi, 2018).

Age-Related Physiological Variation:

White blood cell counts increased with advancing age, with older camels exhibiting higher leukocyte values compared with younger age groups. This pattern is consistent with age-associated immune modulation observed across mammalian species, where cumulative antigen exposure and immune system remodeling lead to elevated baseline leukocyte activity in older individuals (López-Otín et al., 2013; Franceschi et al., 2018). In camels, such changes are generally regarded as physiological rather than pathological, particularly in animals maintained under extensive systems with continuous environmental exposure (Ahmadi-Hamedani et al., 2014).

Age-related increases in erythrocytic parameters, including red blood cell count and packed cell volume, were also observed. These findings suggest that erythropoietic capacity and circulatory efficiency are maintained or enhanced as camels reach full physiological maturity. Similar age-associated trends have been reported in dromedary camels and other large herbivores and are thought to reflect stabilization of oxygen transport mechanisms during adulthood rather than senescent decline (Abdalmula et al., 2023; Farid, 2016).

In contrast, hemoglobin concentration remained relatively stable across age groups, indicating tight regulatory control of oxygen-carrying capacity despite variation in erythrocyte number and volume. This stability aligns with the unique characteristics of camel erythrocytes, which exhibit high deformability and osmotic tolerance, allowing efficient oxygen delivery without large fluctuations in hemoglobin concentration (Schmidt-Nielsen, 1997; Faye & Bengoumi, 2018).

Seasonal Effects on Hematological Regulation:

Seasonal variation exerted a pronounced influence on erythrocytic parameters, with higher red blood cell counts, packed cell volume, and hemoglobin concentration observed during cooler seasons. These changes are commonly attributed to improved hydration status, reduced thermal stress, and lower evaporative water loss during winter, leading to enhanced circulatory efficiency (Amin et al., 2007; Babeker et al., 2013).

Conversely, lower erythrocytic values during warmer seasons likely reflect adaptive plasma volume expansion and thermoregulatory adjustment rather than impaired erythropoiesis. Such seasonal modulation has been consistently reported in camels raised under arid and semi-arid conditions and is considered a key component of physiological adaptation to heat stress (Faye & Bengoumi, 2018).

Seasonal variation in white blood cell counts was also evident. Elevated leukocyte values during transitional seasons may be associated with increased environmental challenges, including nutritional shifts, pathogen exposure, and climatic instability. These fluctuations likely represent adaptive immune responsiveness rather than disease processes, particularly in clinically healthy animals (Martín-Barrasa et al., 2023).

Variation in Erythrocyte Indices:

Significant variation in erythrocyte indices (MCV, MCH, and MCHC) with age and season indicates adaptive regulation of red blood cell morphology and hemoglobin content. Higher MCV and MCH values in younger animals may reflect larger erythrocytes during early adulthood, while reductions in older camels suggest a shift toward more numerous, smaller cells optimized for circulatory efficiency (Kaneko et al., 2008; Farid, 2016).

Seasonal changes in erythrocyte indices further support the concept of physiological plasticity in camel hematology. Adjustments in cell size and hemoglobin concentration across seasons may enhance oxygen transport and thermal tolerance under fluctuating environmental conditions, representing functional adaptation rather than hematological abnormality (Faye & Bengoumi, 2018).

Physiological and Clinical Implications:

The combined effects of age and season observed in this study have important implications for veterinary diagnostics and herd health management. Reliance on generalized hematological reference ranges without consideration of these factors may result in misinterpretation of normal physiological adaptation as pathological change. This is particularly relevant in arid environments, where camels routinely experience environmental stressors that influence blood parameters (Thrall et al., 2012).

The present findings support the need for age- and season-aware physiological interpretation of hematological data in camels raised under extensive pastoral systems. Incorporating these contextual factors into clinical assessment may improve diagnostic accuracy, reduce unnecessary interventions, and enhance understanding of camel adaptive capacity under natural environmental conditions.

Conclusion:

This study demonstrates that hematological parameters in dromedary she-camels raised under arid pastoral conditions in eastern Libya are significantly influenced by both age and seasonal variation. Advancing age was associated with higher leukocyte counts and increased erythrocytic parameters, reflecting age-related physiological modulation of immune activity and oxygen transport capacity.

Seasonal effects were particularly evident in erythrocytic profiles, with cooler seasons showing hematological patterns consistent with improved hydration status and reduced thermal stress.

The observed variation in erythrocyte indices across age groups and seasons highlights the physiological plasticity of camel hematology and underscores the role of adaptive regulation in maintaining circulatory efficiency and homeostasis under fluctuating environmental conditions. Importantly, hemoglobin concentration remained relatively stable across age groups, indicating tight regulation of oxygen-carrying capacity despite changes in red blood cell number and volume.

Overall, these findings emphasize that hematological values in dromedary camels cannot be interpreted independently of age and season. Incorporating these factors into physiological and clinical assessment is essential to avoid misclassification of normal adaptive responses as pathological conditions. The study provides region-specific physiological evidence that supports age- and season-aware interpretation of camel hematology and contributes to improved health assessment and management of camels raised under arid pastoral systems.

References:

1. Abdalmula, A., Shmela, M., Alnagar, F., Buker, A., Benashour, F., & Abograra, I. (2023). Blood profile in normal one-humped dromedary camels in Libya: Effect of age variation. Alqalam Journal of Medical and Applied Sciences, 6(1), 219–224. https://doi.org/10.5281/zenodo.7876591
2. Ahmadi-Hamedani, M., Ghazvinian, K., Kokhaei, P., Barati, M., & Mahdavi, A. (2014). Comparison of effects of age and sex on serum protein electrophoretic pattern in one-humped camels (Camelus dromedarius). Open Veterinary Journal, 4(1), 4–8. https://doi.org/10.5455/ovj.2014.v4.i1.4
3. Amin, Z. M., Nawito, M. A., & Al-Hadrami, G. A. (2007). Seasonal variation in blood constituents of one-humped camel (Camelus dromedarius). Pakistan Journal of Biological Sciences, 10(12), 1895–1899. https://doi.org/10.3923/pjbs.2007.1895.1899
4. Babeker, H. A., Ali, A. O., Mohammed, A. E., & Reid, S. (2013). Seasonal variation in serum biochemical profiles of dairy camels in Sudan. Journal of Camel Practice and Research, 20(2), 135–141.
5. Farid, M. F. A. (2016). Hematological and biochemical characteristics of dromedary camels. Journal of Camel Practice and Research, 23(2), 217–223.
6. Faye, B., & Bengoumi, M. (2018). Camel clinical biochemistry and hematology. Springer. https://doi.org/10.1007/978-3-319-95525-6
7. Franceschi, C., Garagnani, P., Parini, P., Giuliani, C., & Santoro, A. (2018). Inflammaging: A new immune–metabolic viewpoint for age-related diseases. Nature Reviews Endocrinology, 14(10), 576–590. https://doi.org/10.1038/s41574-018-0059-4
8. Kaneko, J. J., Harvey, J. W., & Bruss, M. L. (2008). Clinical biochemistry of domestic animals (6th ed.). Academic Press.
9. López-Otín, C., Blasco, M. A., Partridge, L., Serrano, M., & Kroemer, G. (2013). The hallmarks of aging. Cell, 153(6), 1194–1217. https://doi.org/10.1016/j.cell.2013.05.039
10. Martín-Barrasa, J. L., Tejedor-Junco, M. T., Cabrera, S., Morales, M. F., Melián, A., & Corbera, J. A. (2023). Haematological and biochemical blood reference values for Canary Island camels (Camelus dromedarius). Saudi Journal of Biological Sciences, 30(6), 103677. https://doi.org/10.1016/j.sjbs.2023.103677
11. Schmidt-Nielsen, K. (1997). Animal physiology: Adaptation and environment (5th ed.). Cambridge University Press.
12. Thrall, M. A., Weiser, G., Allison, R. W., & Campbell, T. W. (2012). Veterinary hematology and clinical chemistry (2nd ed.). Wiley-Blackwell.